

DYNAMIC CRACK PROPAGATION UNDER SHEAR LOADING

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Dynamic fracture in solids has been a topic of enormous interest; numerous investigators have examined the problem experimentally, analytically as well as through numerical simulations. Much of this work has been aimed at cracks growing under opening mode or mode I type of loading. This is primarily due to the fact that crack growth in homogeneous materials is seldom observed under locally shear dominant conditions; in fact, this observation is the basis for the usually postulated *criterion of local symmetry* that is used to determine crack paths under mixed-mode loading even under quasi-static conditions. The reasons for preferring the locally opening mode of crack growth are rooted in the energetics of fracture: the energy required to grow a crack normal to the direction of local tension is smaller than the energy required to drive the crack under local shear.

In this paper, we describe an experiment designed to promote shear fracture in a homogeneous, isotropic specimen by introducing a groove to trap the mode-II crack to grow along the groove. The specimens were impacted with a 50 mm diameter 100 mm long polycarbonate projectile, accelerated to speeds in the range of 20 to 80 m/s by an air-gun. We have promoted the growth of a shear driven crack in a specimen made of polymethylmethacrylate (PMMA) and examined the growth of shear cracks. It was found that these shear driven cracks grow at much larger speeds than typical brittle mode I cracks in the same material. In PMMA, mode I cracks grow at a limiting speed of about 700 m/s, lower than the elastic wave dictated limit of the Rayleigh wave speed. On the other hand, the speed of the shear cracks were determined to be in the range from the shear wave speed to the dilatational wave speed. Examination of the fracture surface morphology indicated that two different types of shear driven cracks could be propagated. One type of shear driven crack was simply a coalescence of opening mode (brittle) cracks that nucleated at an angle to the maximum shear plane ahead of the main crack. These are typically referred to as *en echelon* cracks and have been observed in rocks and earthquakes. The second type of shear driven cracks, are grown from an initial crack, but without the formation of *en echelon* cracks; a shear stress driven ductile tearing mechanism appears to be responsible for this mode of crack growth. The observed crack speeds are discussed in terms of the fracture mechanisms.